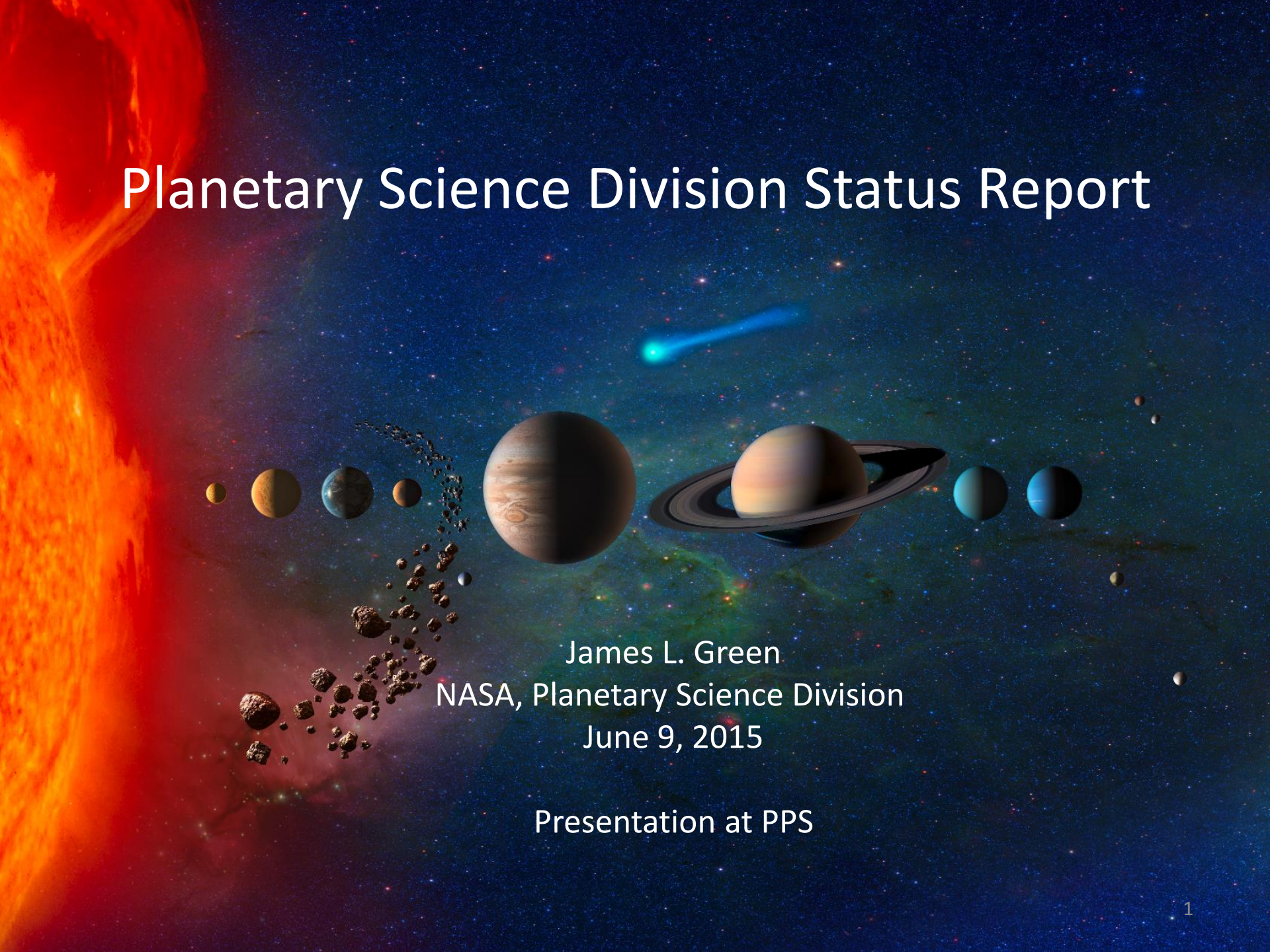


# Planetary Science Division Status Report



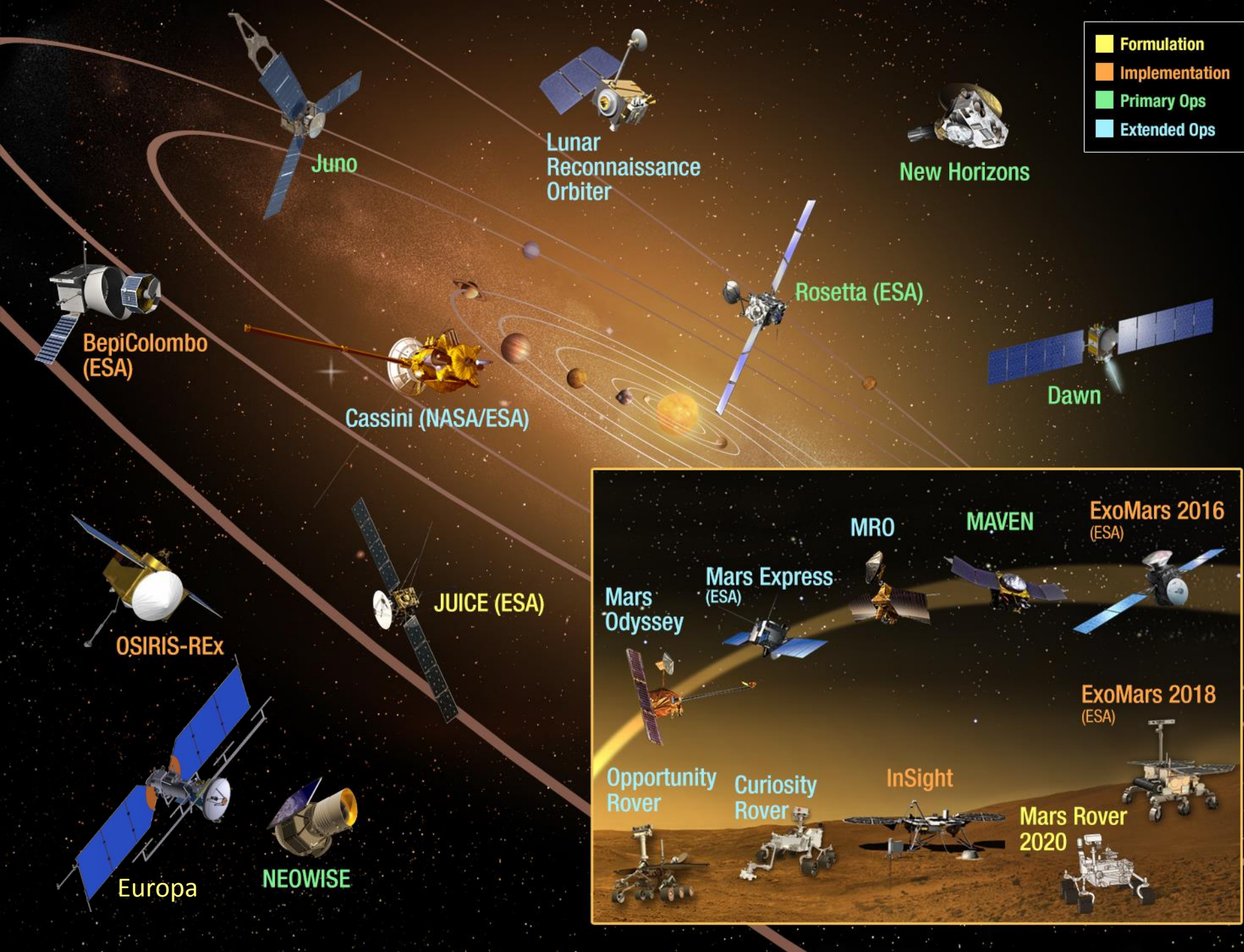
James L. Green  
NASA, Planetary Science Division  
June 9, 2015

Presentation at PPS

# Outline

- Mission events & highlights
- Discovery and New Frontiers Status
- Mars Program Status
- Recent Europa Activities





# Planetary Science Missions Events

## 2014

July – *Mars 2020* Rover instrument selection announcement

\* **Completed**

August 6 – 2<sup>nd</sup> Year Anniversary of *Curiosity* Landing on Mars

September 21 – *MAVEN* inserted in Mars orbit

October 19 – Comet Siding Spring encountered Mars

September – *Curiosity* arrives at Mt. Sharp

November 12 – ESA's *Rosetta* mission lands on Comet Churyumov–Gerasimenko

December 2/3 – Launch of *Hayabusa-2* to asteroid 1999 JU<sub>3</sub>

## 2015

March 6 – *Dawn* inserted into orbit around dwarf planet Ceres

April 30 – *MESSENGER* spacecraft impacts Mercury

May 26 – Europa mission instruments selected

July 14 – *New Horizons* flies through the Pluto system

September – Discovery 2014 Step 1 selection

December 7 – *Akatsuki* inserted into orbit around Venus

## 2016

January – Launch of ESA's *ExoMars Trace Gas Orbiter*

March – Launch of *InSight*

July – *Juno* inserted in Jupiter orbit

July – ESA's *Bepi Colombo* launch to Mercury

September – Discovery 2014 Step 2 selection

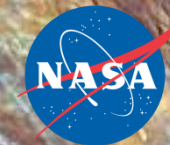
September – *InSight* Mars landing

September – Launch of Asteroid mission *OSIRIS – REx* to asteroid Bennu

September – *Cassini* begins to orbit between Saturn's rings & planet



# MESSENGER: BY THE NUMBERS



**8.73** BILLION  
miles traveled

**6** FLYBYS  
of the  
inner planets

**32.5** TRIPS  
around  
the Sun

**291,008**  
IMAGES  
returned to Earth

**41.25** MILLION  
SHOTS  
by the Mercury  
Laser Altimeter

**10** TERABYTES  
of science data  
released to public

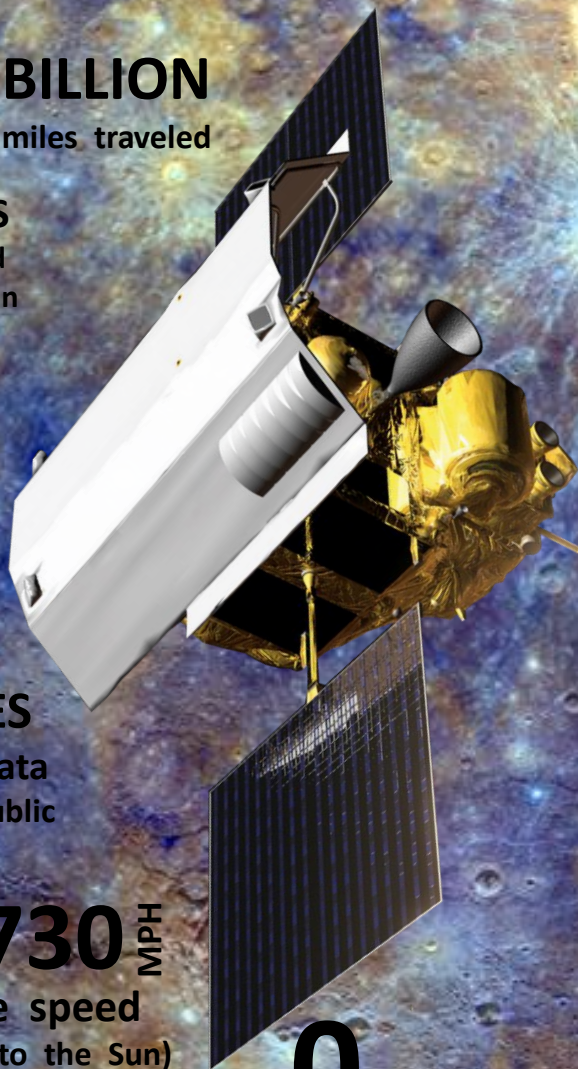
**8** MERCURY  
SOLAR DAYS  
and

**1,504** EARTH  
DAYS  
in orbit

**91,730** MPH  
average speed  
(relative to the Sun)

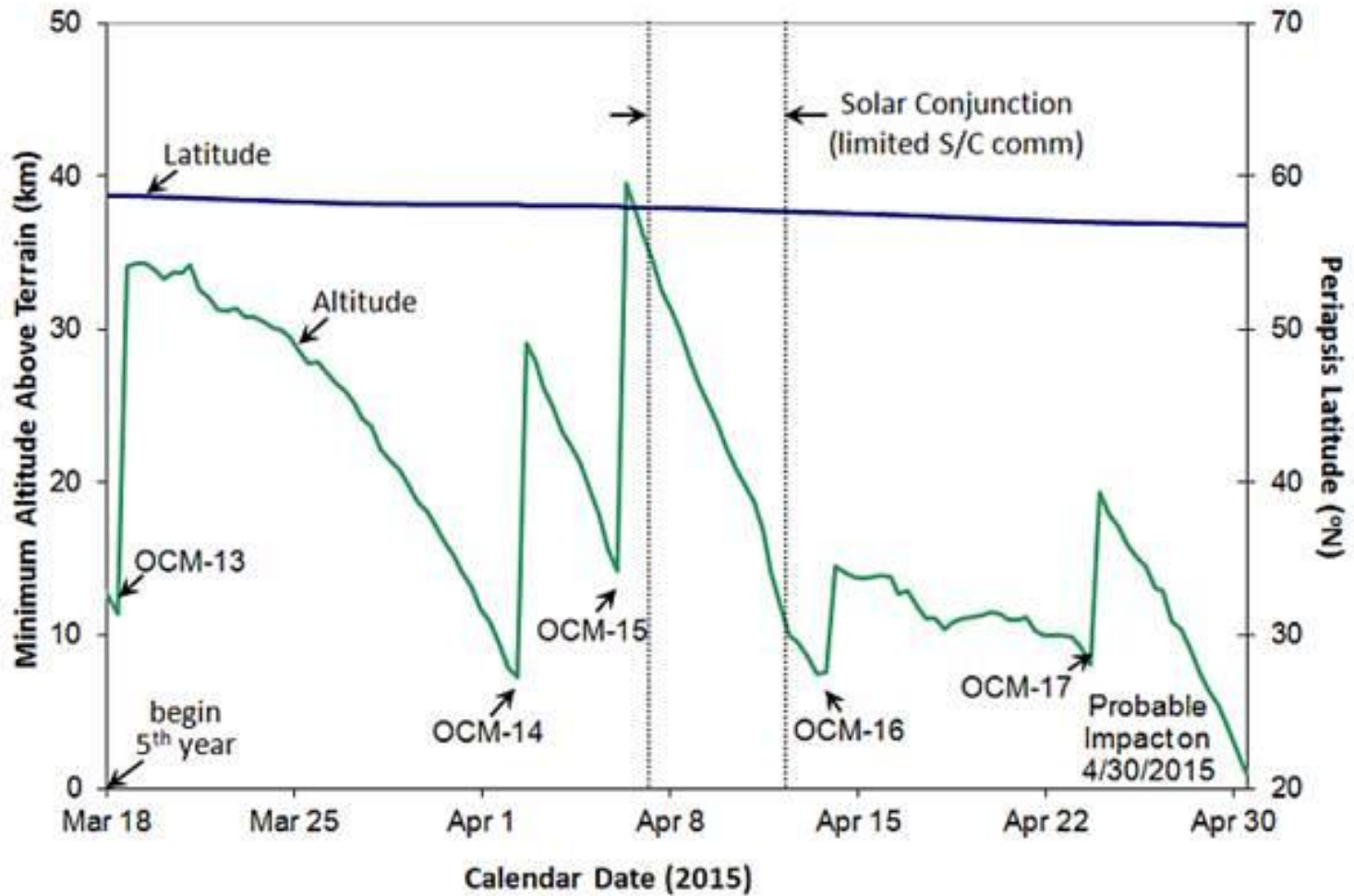
**4,100**  
ORBITS  
of Mercury  
completed

**0** MILES  
lowest altitude  
above Mercury

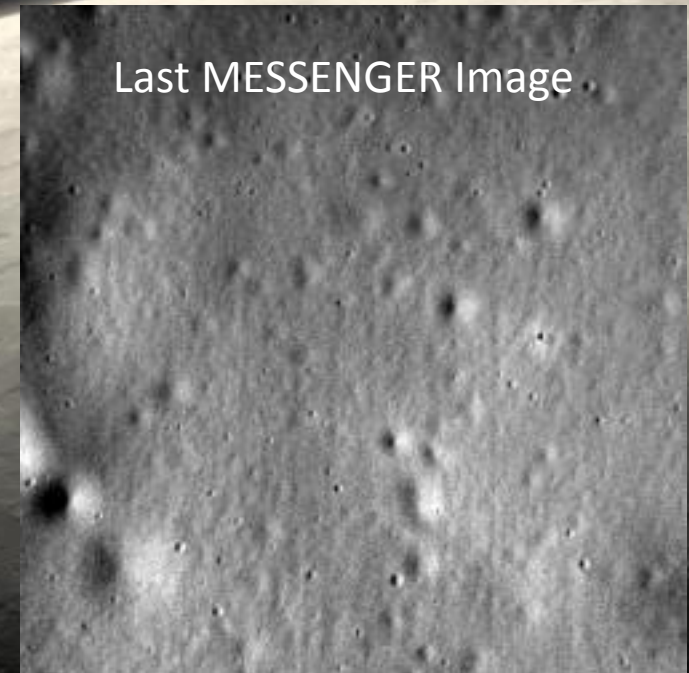
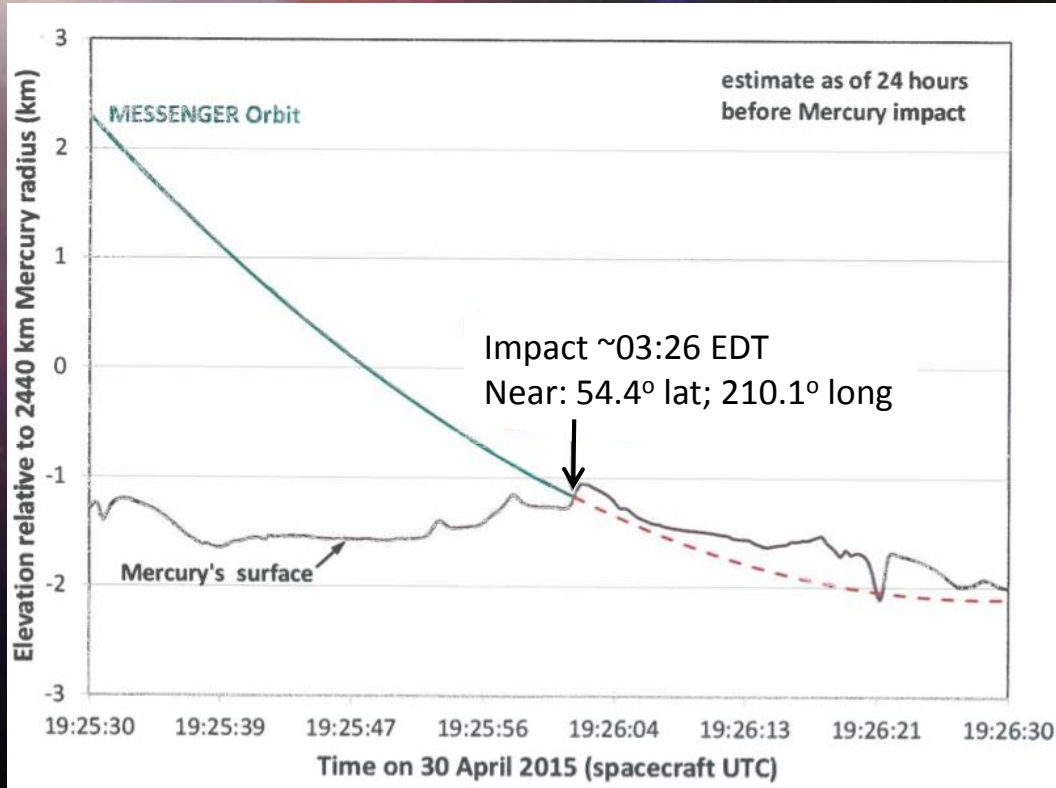
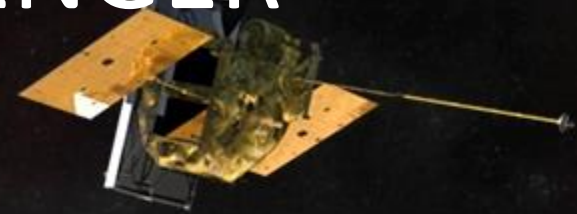


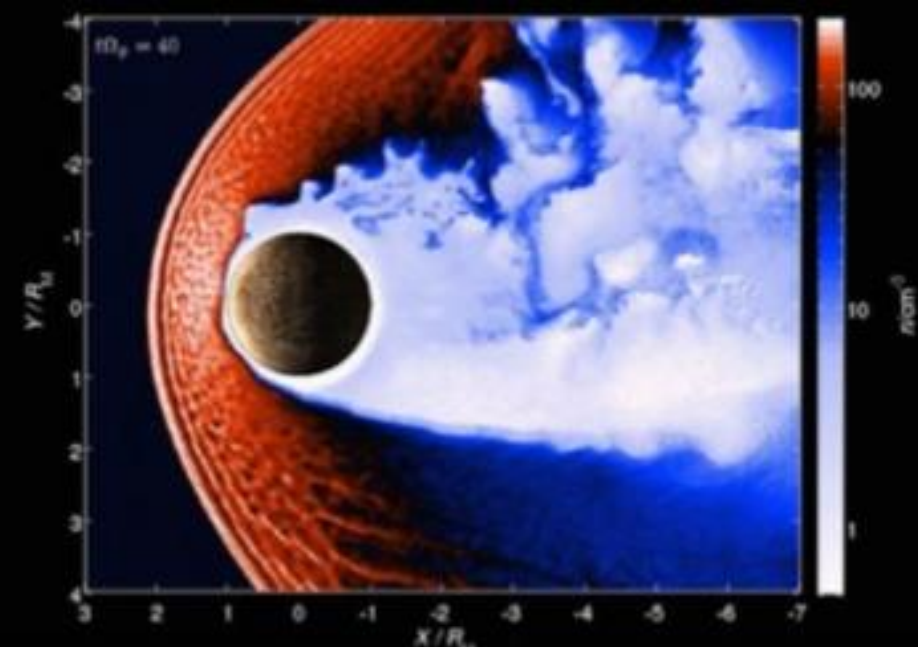


# MESSENGER

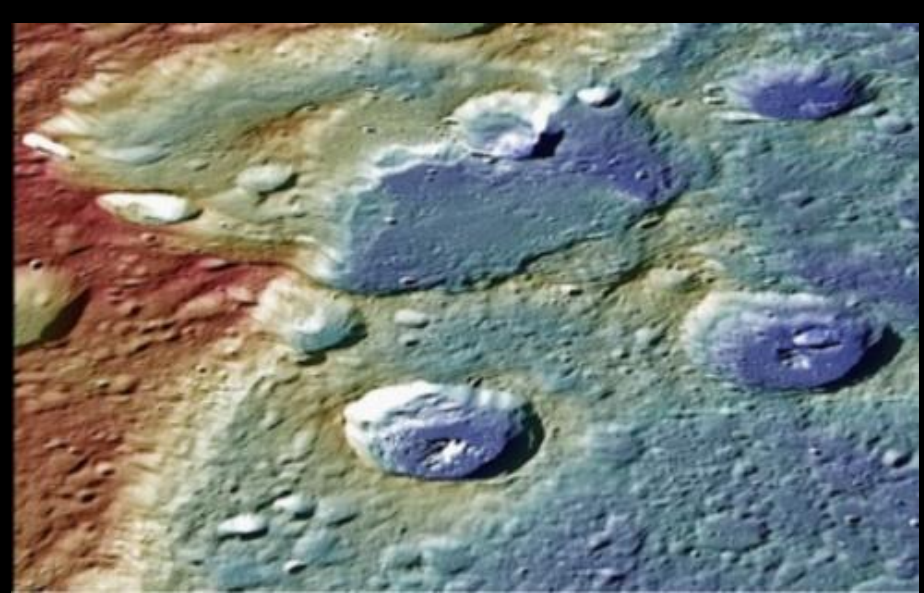


# EOM for MESSENGER

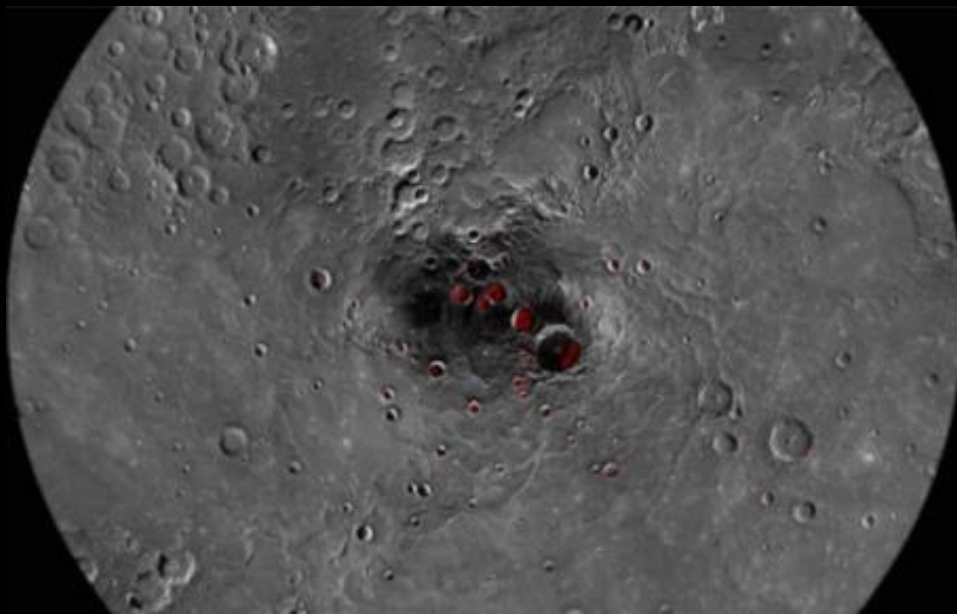




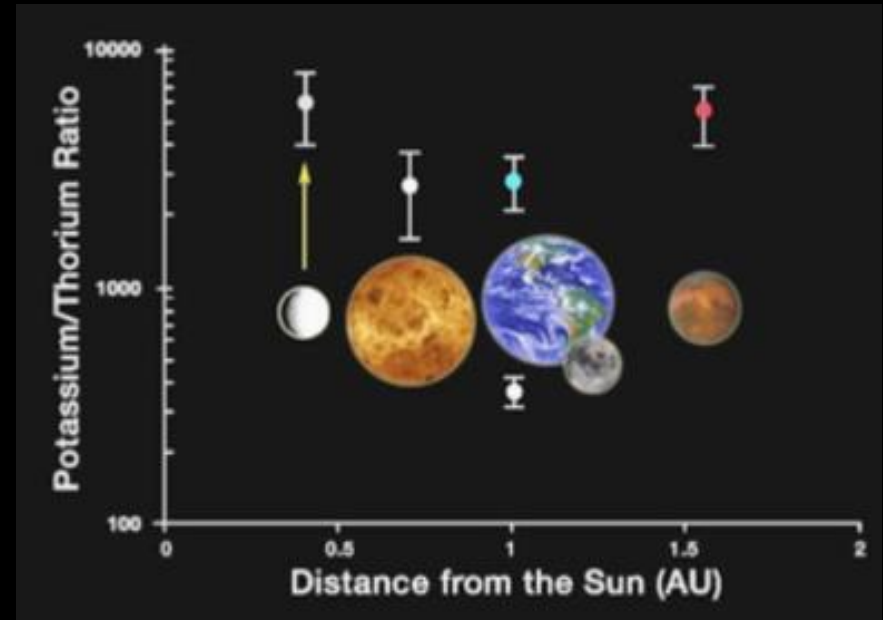
Dynamic Magnetosphere



Global Contraction



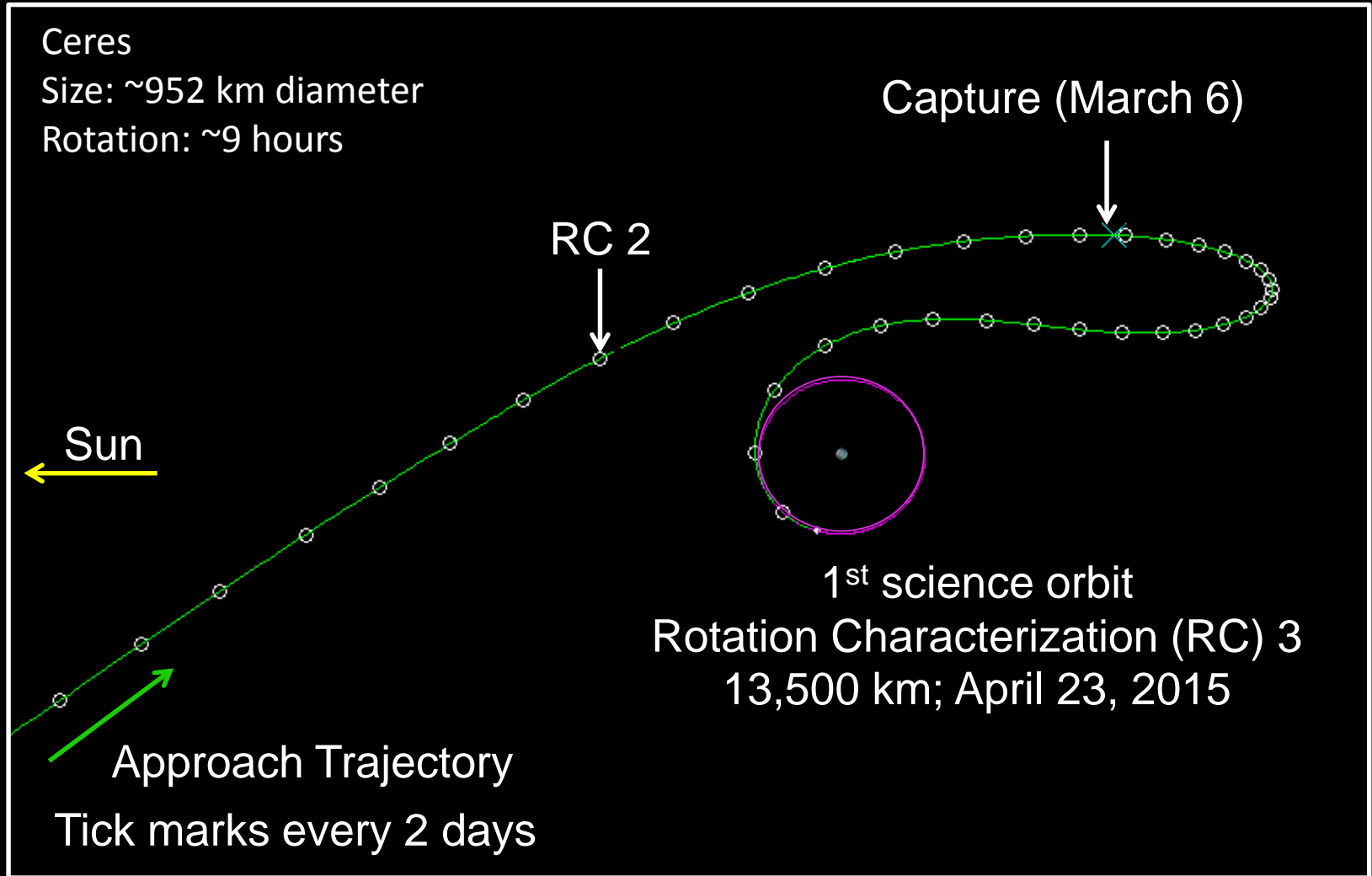
Polar Deposits



Volatile-Rich Planet



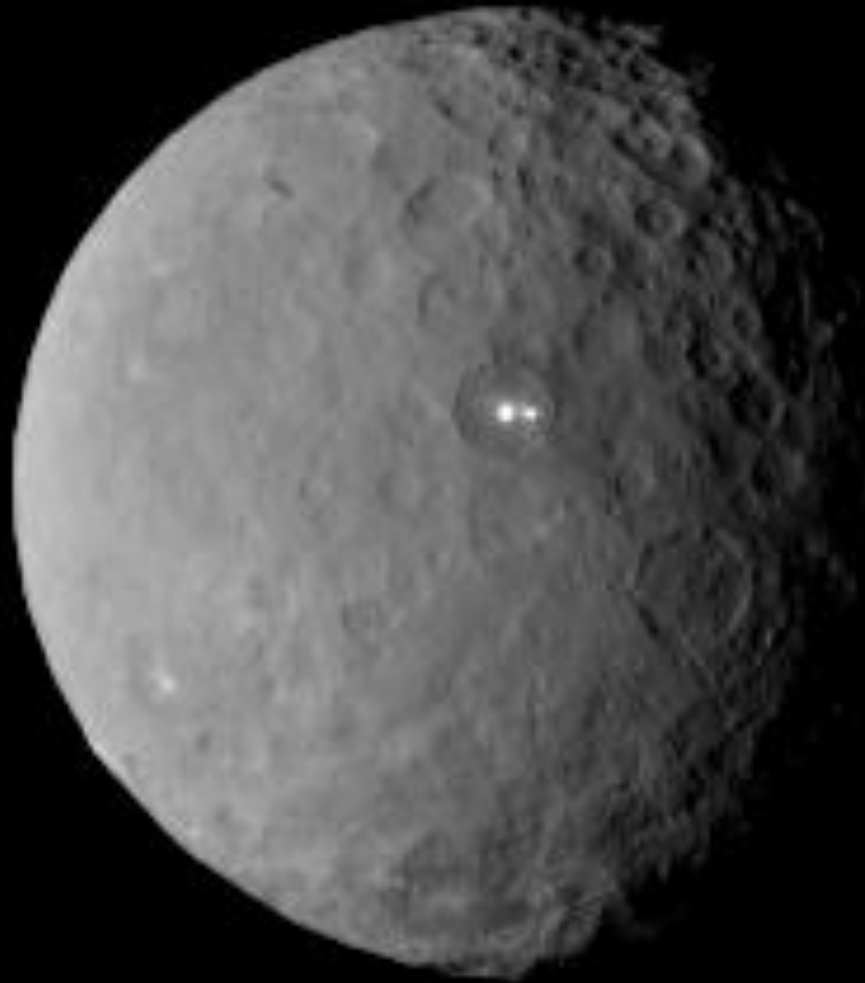
# Dawn's Approach



RC 2

Feb 19

Resolution  
4 km/pixel

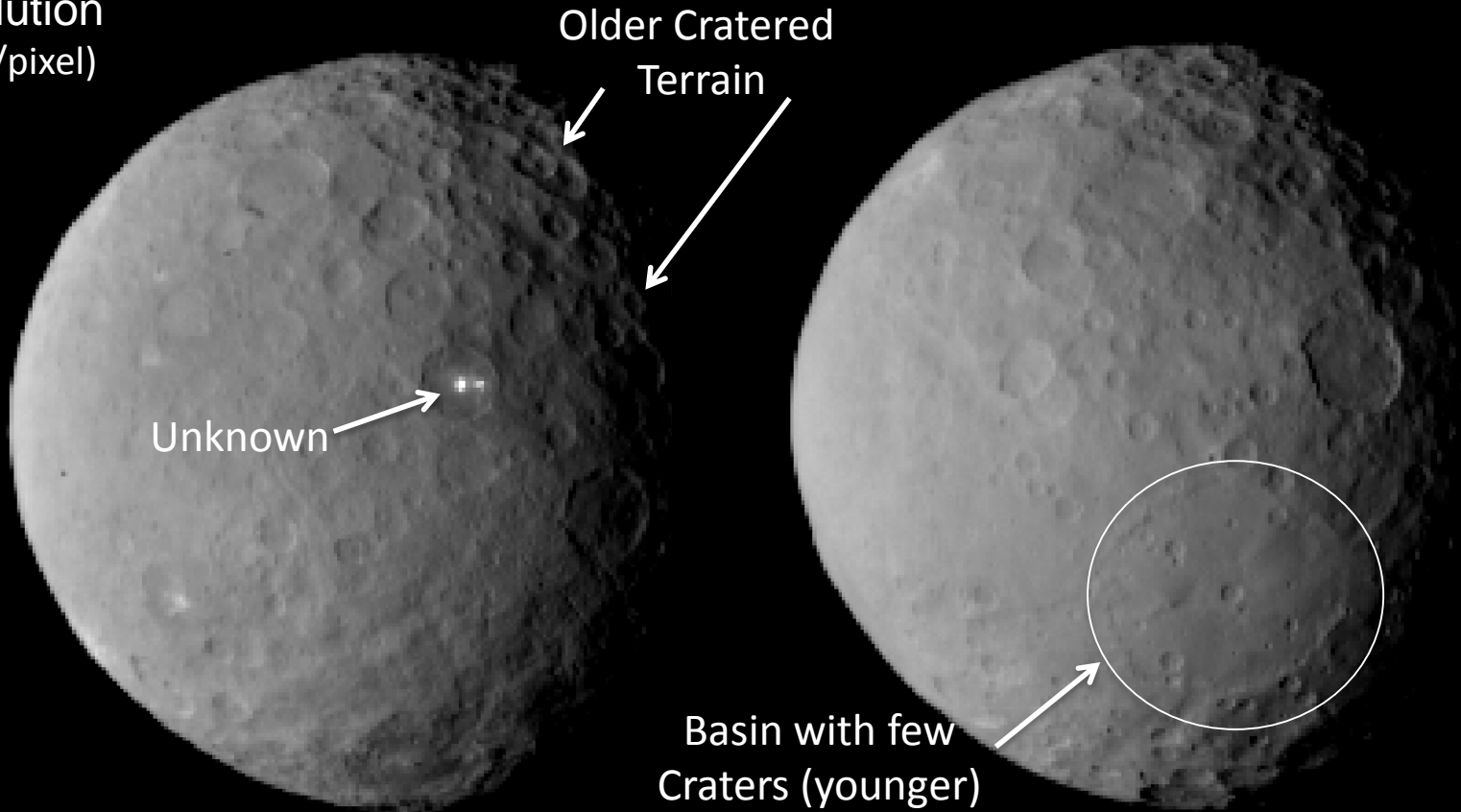




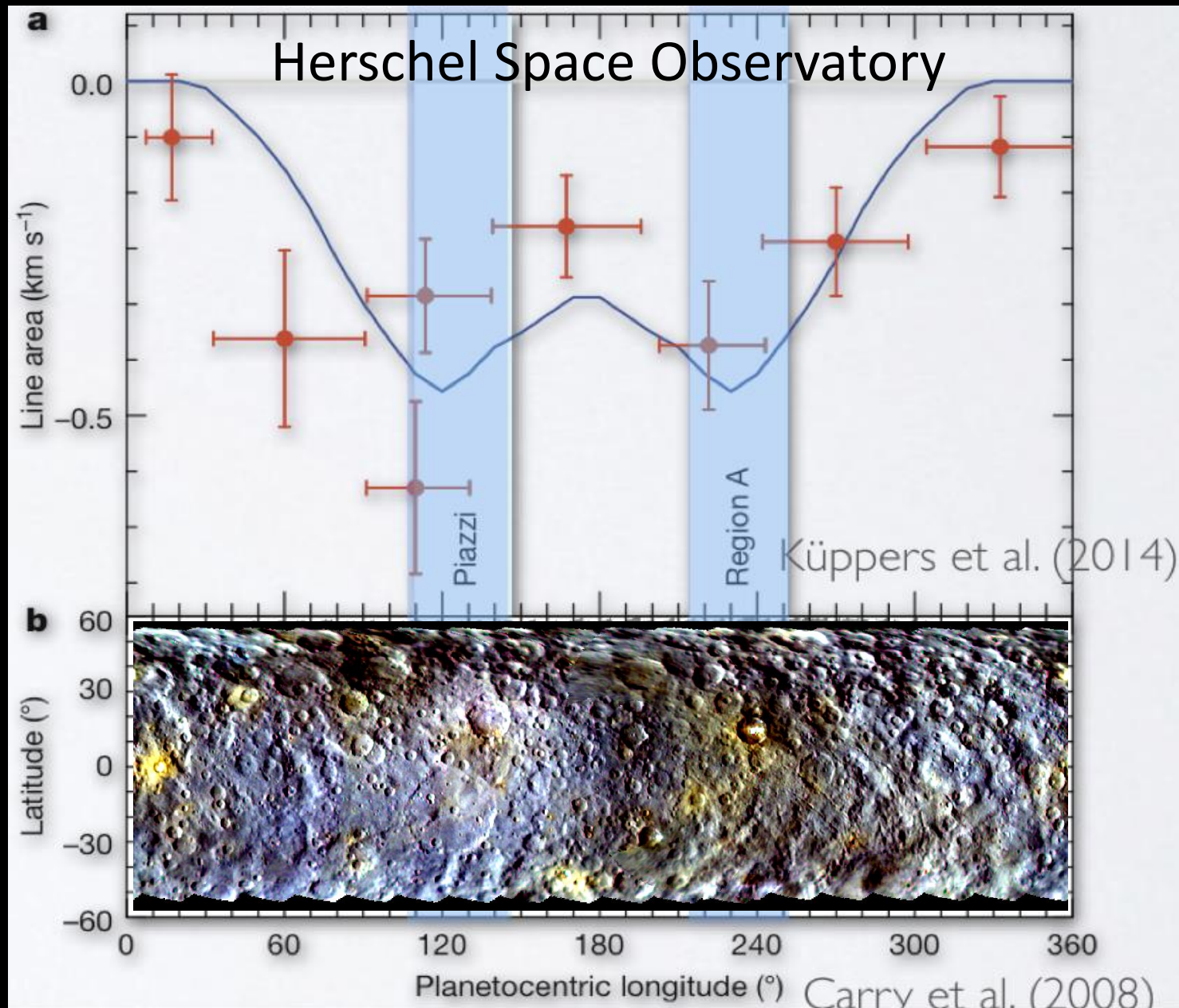
# The Types of Terrain

RC 2 - Feb 19

7 x Hubble  
Resolution  
(4 km/pixel)

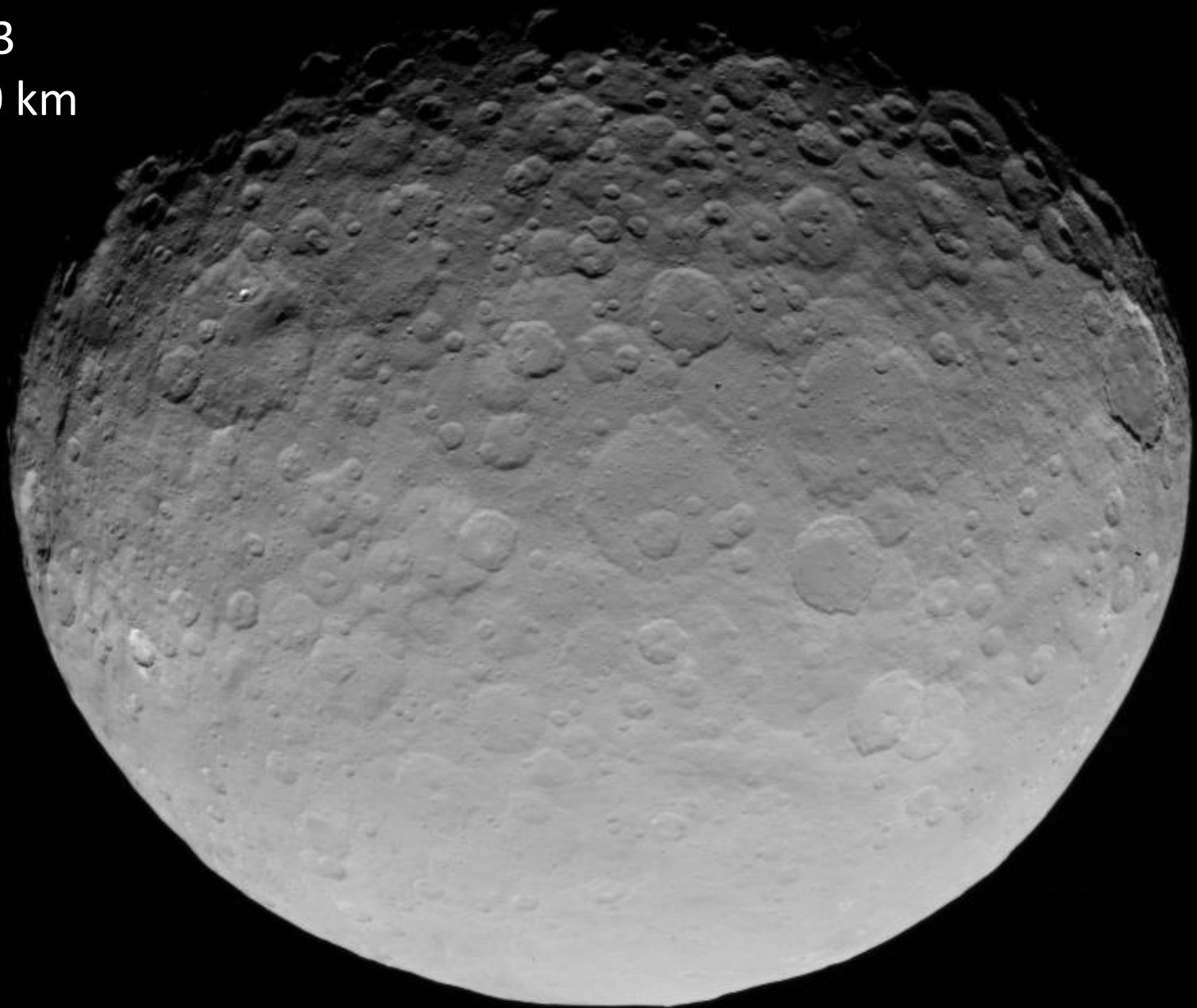


# Mapping the Water Vapor to Ceres





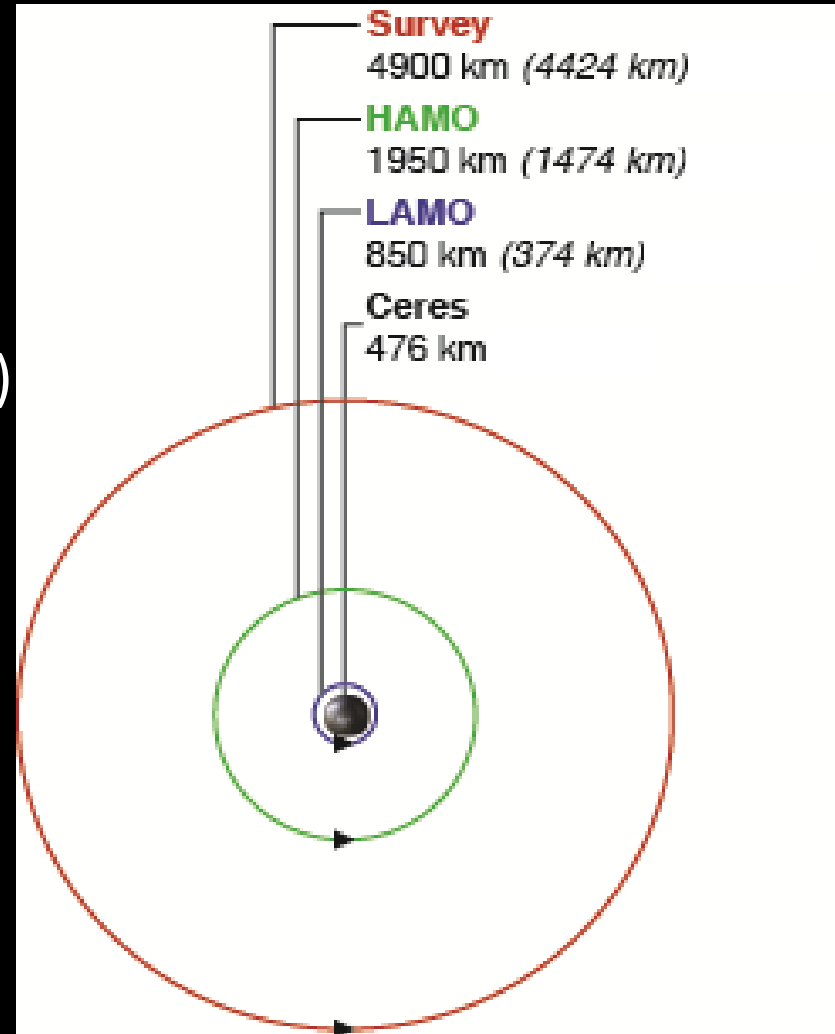
RC 3  
13,500 km



# Ceres Science Orbits

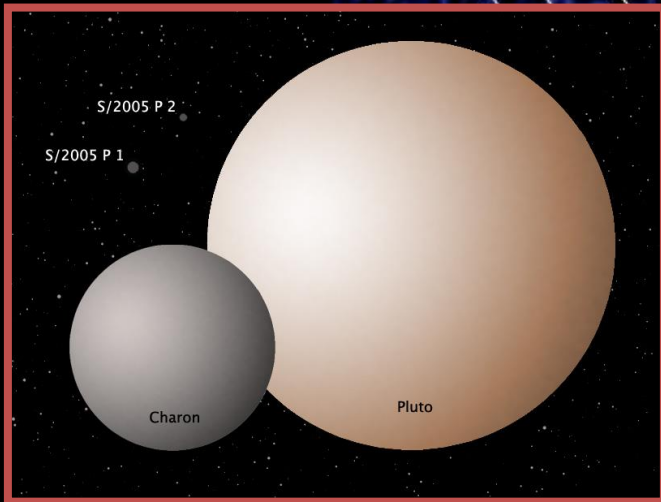
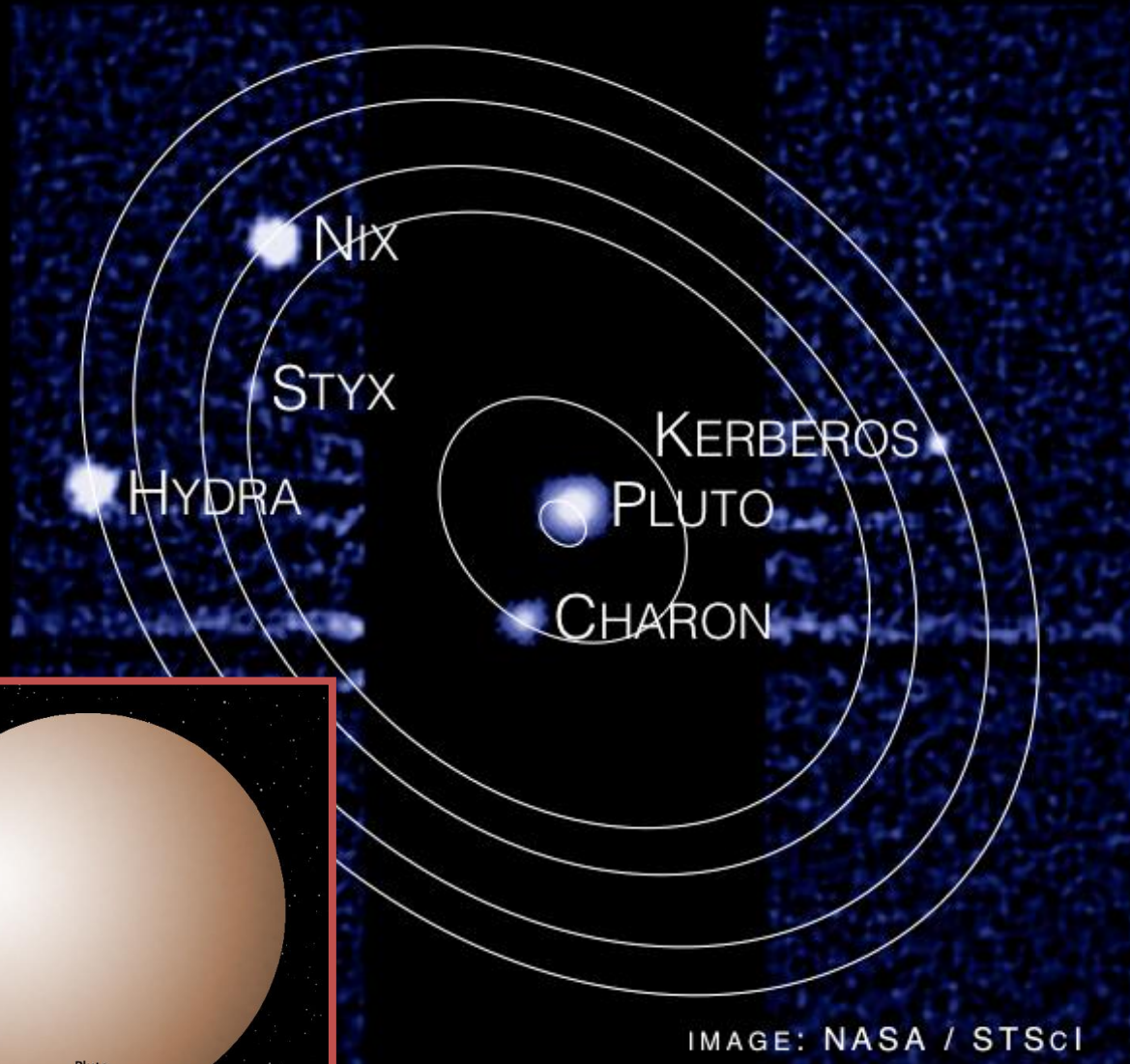
- Rotation Characterization 3
  - Duration 1 orbit (20 days)
- Survey Orbit – starting June 5th
  - Duration 7 orbits (22 days)
- High Altitude Mapping Orbit (HAMO)
  - Duration 70 orbits (56 days)
- Low Altitude Mapping Orbit (LAMO)
  - Duration 404 orbits (92 days)

Total of 406 days of operations  
are planned at Ceres





# The New Pluto System



# NH LORRI OPTICAL NAVIGATION CAMPAIGN 3

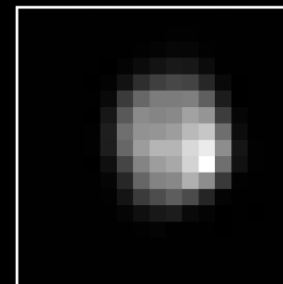
PROPER MOTION - IMAGE DECONVOLVED



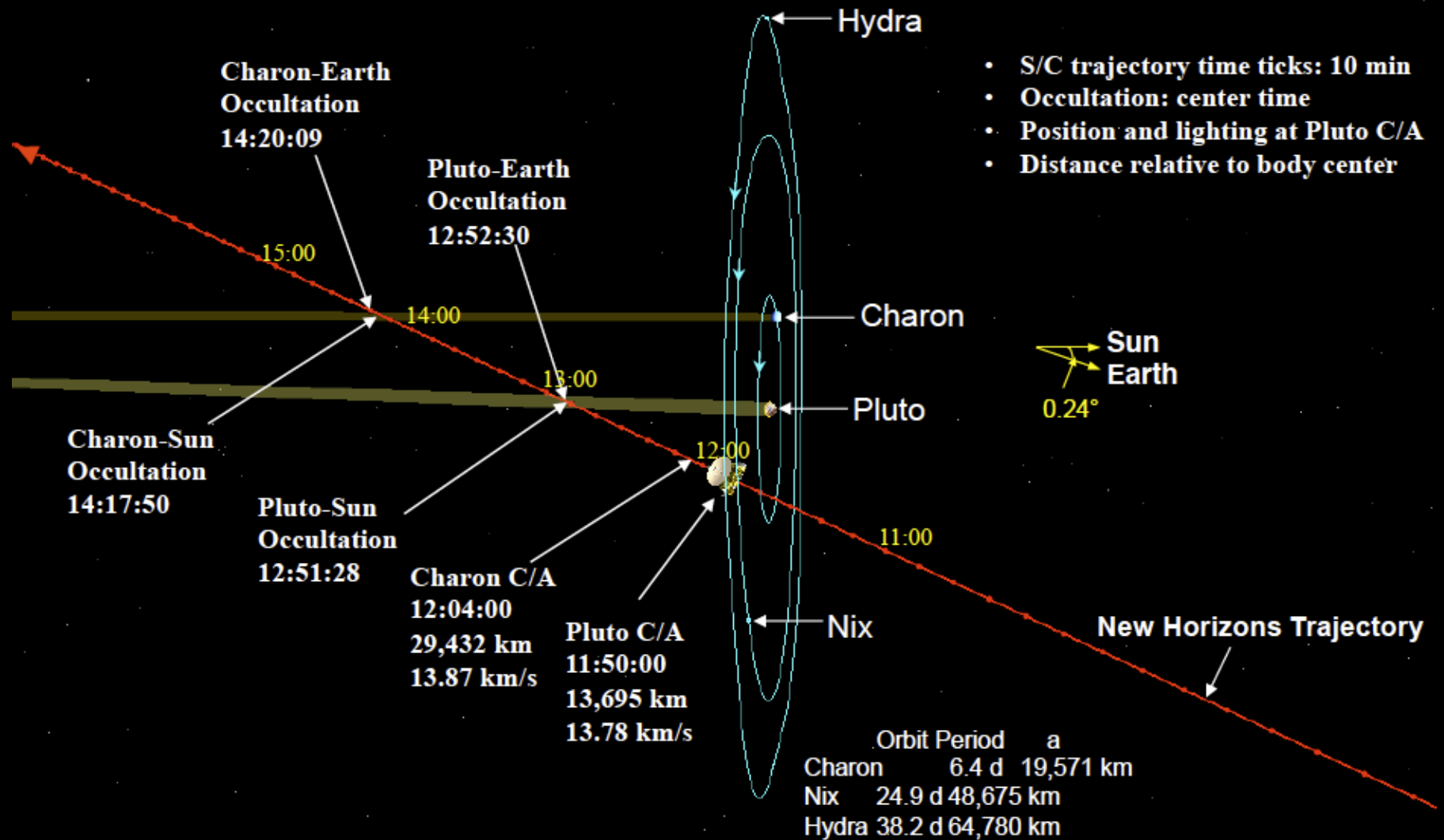
2015-04-12 03:27:00 UTC

DISTANCE: 111,179,688 KM  
CLOSEST APPROACH: 93.35 days

Pluto Zoom x3



# Closest Approach On July 14, 2015





**New Horizons  
Pluto Flyby**

Hydra  
**COMPUTER  
SIMULATION**

Kerberos

New Horizons



2015-07-14 11:45:38.7 UTC

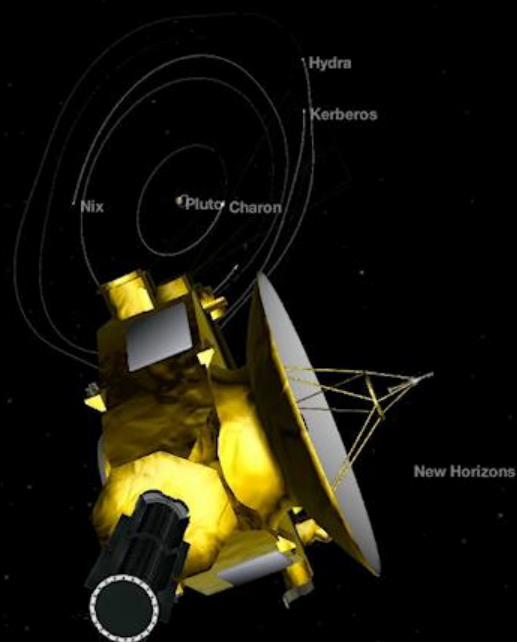
**DISTANCE TO PLUTO**  
**8,238.3 Miles**  
**CLOSEST APPROACH**  
**-00h 05m 25.8s**

**New Horizons  
Pluto Flyby**

**COMPUTER  
SIMULATION**



2015-07-14 04:59:37.5 UTC



**DISTANCE TO PLUTO**  
**210,779.6 Miles**  
**CLOSEST APPROACH**  
**-06h 51m 27.1s**

# Discovery and New Frontiers Status



# Discovery and New Frontiers

- ◆ Address high-priority science objectives in solar system exploration
- ◆ Opportunities for the science community to propose full investigations
- ◆ Fixed-price cost cap full and open competition missions
- ◆ Principal Investigator-led project



- ◆ Established in 1992
- ◆ **\$450M cap** per mission excluding launch vehicle and operations phase (FY15\$)
- ◆ Open science competition for all solar system objects, except for the Earth and Sun



- ◆ Established in 2003
- ◆ **\$850M cap** per mission excluding launch vehicle and operations phase (FY15\$)
- ◆ Addresses high-priority investigations identified by the National Academy of Sciences

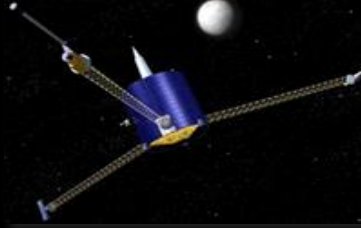
# Discovery Program

Completed

**Mars evolution:  
Mars Pathfinder (1996-1997)**



**Lunar formation:  
Lunar Prospector (1998-1999)**



**NEO characteristics:  
NEAR (1996-1999)**



**Solar wind sampling:  
Genesis (2001-2004)**



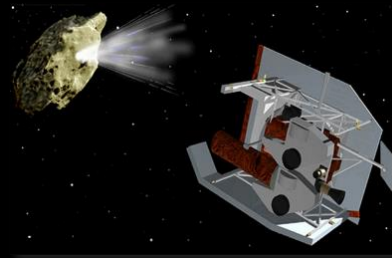
**Comet diversity:  
CONTOUR (2002)**



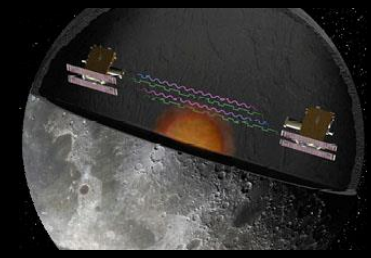
**Nature of dust/coma:  
Stardust (1999-2011)**



**Comet internal structure:  
Deep Impact (2005-2012)**

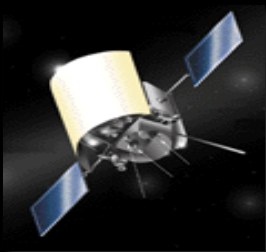


**Lunar Internal Structure  
GRAIL (2011-2012)**



Completed

**Mercury environment:  
MESSENGER (2004-2015)**



**Main-belt asteroids:  
Dawn (2007-2016)**



**Lunar surface:  
LRO (2009-TBD)**



**ESA/Mercury Surface:  
Strofió (2016-TBD)**



**Mars Interior:  
InSight (2016-TBD)**



# Status of Discovery Program

## Discovery 2014 - Proposals in review for September Selection

- About 3-year mission cadence for future opportunities

## Missions in Development

- *InSight*: Confirmation to begin ATLO on March 24, 2015
- Strofio: Delivered to SERENA Suite (ASI) for BepiColombo

## Missions in Operation

- *Dawn*: In orbit around Ceres as of March 6

## Missions in Extended Operations

- *MESSENGER*: Completed low altitude science operations before impact with Mercury
- *LRO*: In stable elliptical orbit, passing low over the lunar south pole.



# New Frontiers Program

1<sup>st</sup> NF mission  
New Horizons:

Pluto-Kuiper Belt



Launched January 2006  
Flyby July 14, 2015  
PI: Alan Stern (SwRI-CO)

2<sup>nd</sup> NF mission  
JUNO:

Jupiter Polar Orbiter



Launched August 2011  
Arrives July 2016  
PI: Scott Bolton (SwRI-TX)

3<sup>rd</sup> NF mission  
OSIRIS-REx:

Asteroid Sample Return



To be launched: Sept. 2016  
PI: Dante Lauretta (UA)

# Status of New Frontiers Program

Next New Frontiers AO - to be released by end of Fiscal Year 2016

- New ROSES call for instrument/technology investments released
- Candidate mission list and nuclear power sources under consideration

Missions in Development - OSIRIS REx

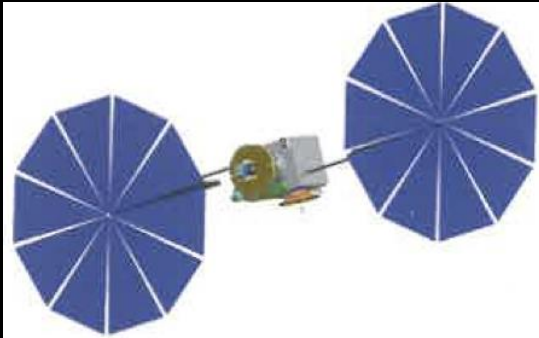
- Launch in Sept 2016 & encounter asteroid Bennu in Oct 2018.
- Operate at Bennu for over 400 days.
- Returns a sample in 2023 that scientists will study for decades with ever more capable instruments and techniques.

Missions in Operation

- New Horizons:
  - Spacecraft is 32 AU from the sun and <1 AU from Pluto
  - Pluto system encounter July 14, 2015
  - HST identified 2 KBO's beyond Pluto for potential extended mission
- Juno:
  - Spacecraft is 4.5 AU from the sun and 1.5 AU from Jupiter
  - Orbit insertion is July 4, 2016

# New Frontiers #4 Focused Missions

Comet Surface  
Sample Return



Lunar South Pole  
Aitken Basin Sample  
Return



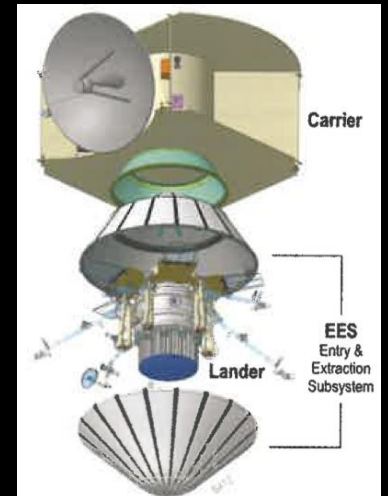
Trojan Tour &  
Rendezvous



Saturn Probes



Venus In-Situ Explorer

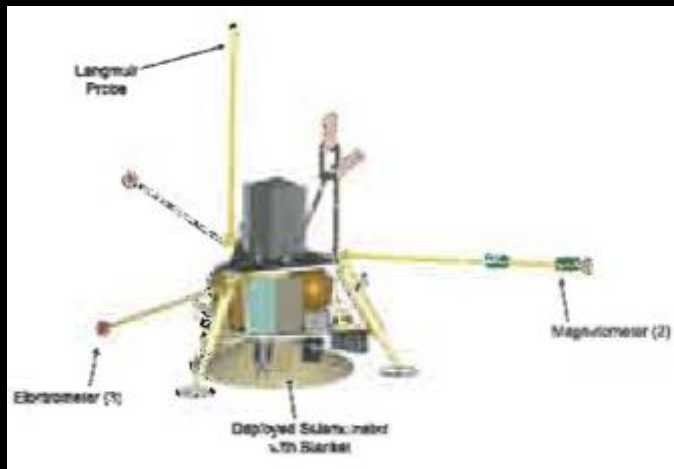




# New Frontiers #5 Focused Missions

- Added to the remaining list of candidates:

Lunar Geophysical Network



Io Observer



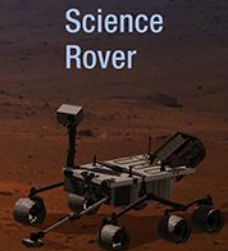
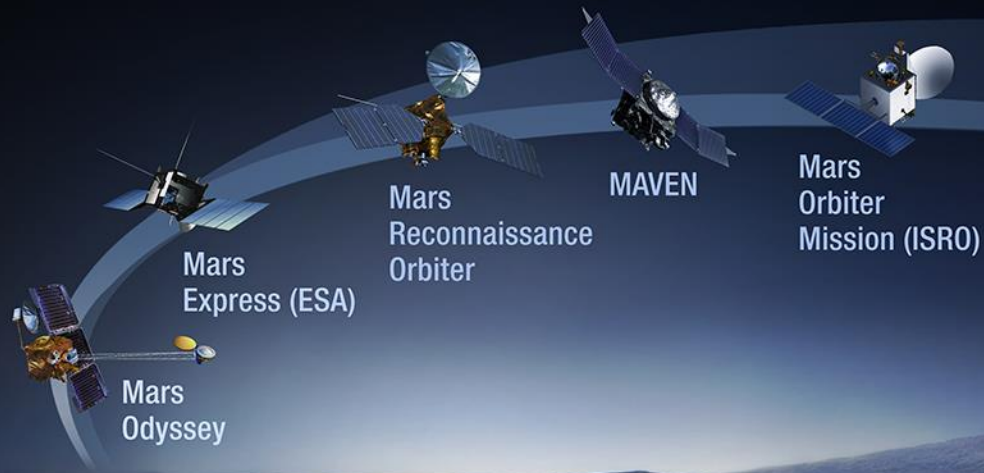
# Mars Program Status

Operational 2001–2015

2016

2018

2020



*Follow the Water*

*Explore Habitability*

*Seek Signs of Life*

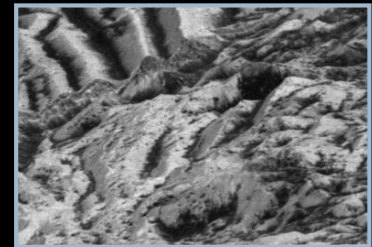
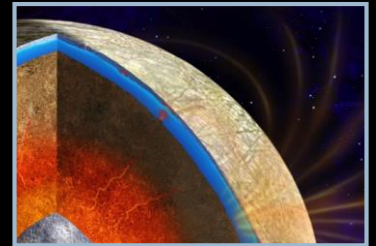
*Prepare for Future Human Explorers*

# Europa Activities

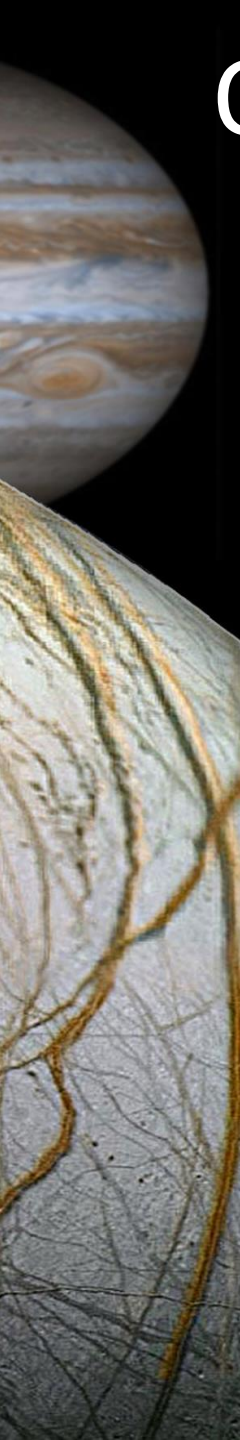


# Europa Multi-Flyby Mission Science Goal & Objectives

- **Goal: Explore Europa to investigate its habitability**
- **Objectives:**
  - **Ice Shell & Ocean:** Characterize the ice shell and any subsurface water, including their heterogeneity, ocean properties, and the nature of surface-ice-ocean exchange
  - **Composition:** Understand the habitability of Europa's ocean through composition and chemistry
  - **Geology:** Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities
  - **Reconnaissance:** Characterize scientifically compelling sites, and hazards, for a potential future landed mission to Europa

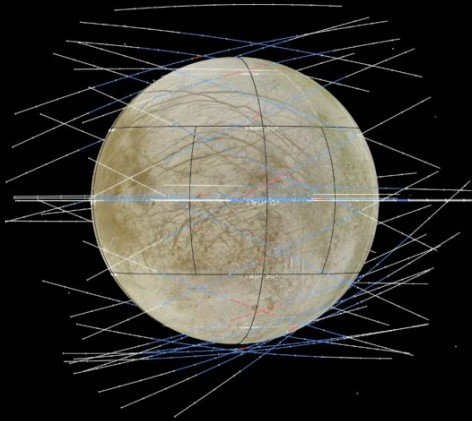


# Overview of Selected Proposals



Instrument Type	Name	PI	instituion
Plasma	PIMS	Joseph Westlake	APL
Magnetometer	ICEMAG	Carol Raymond	JPL
Shortwave IR Spectrometer	MISE	Diana Blaney	JPL
Camera	EIS	Elizabeth Turtle	APL
Ice Penetrating Radar	REASON	Don Blankenship	Univ. Texas/JPL
Thermal Imager	E-THEMIS	Phil Christensen	ASU/Ball
Neutral Mass Spectrometer	MASPEX	Hunter Waite	SWRI
UV Spectrograph	E-UVS	Kurt Retherford	SWRI
Dust Analyzer	SUDA	Sascha Kempf	Univ. Colorado

# Europa Multi-Flyby Mission Concept Overview



## Science

### Objective

### Description

#### Ice Shell & Ocean

Characterize the ice shell and any subsurface water, including their heterogeneity, and the nature of surface-ice-ocean exchange

#### Composition

Understand the habitability of Europa's ocean through composition and chemistry.

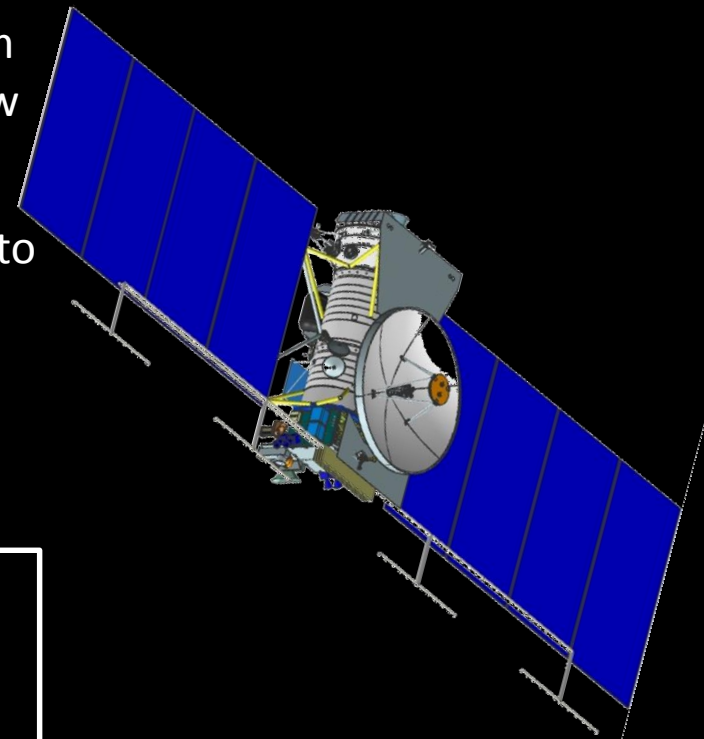
#### Geology

Understand the formation of surface features, including sites of recent or current activity, and characterize high science interest localities.

#### Recon

Characterize scientifically compelling sites, and hazards for a potential future landed mission to Europa

- Conduct 45 low altitude flybys with lowest 25 km (less than the ice crust) and a vast majority below 100 km to obtain global regional coverage
- Traded enormous amounts of fuel used to get into Europa orbit for shielding (lower total dose)
- Simpler operations strategy
- No need for real time down link



## Key Technical Margins

\*37 - 41%

**Mass**

40%

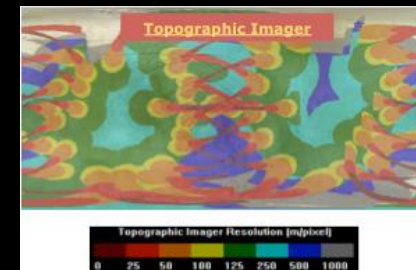
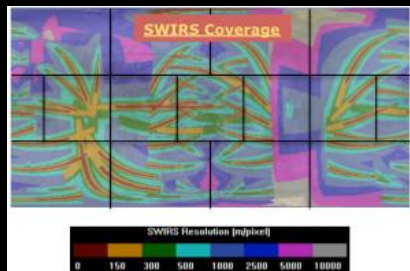
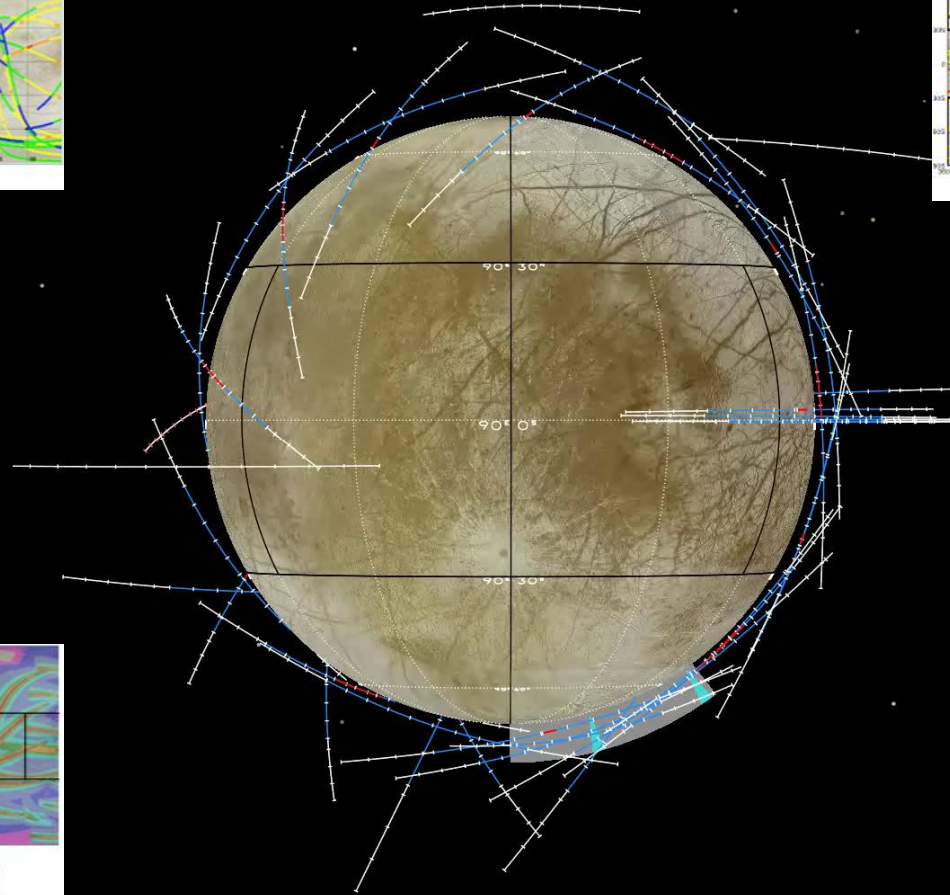
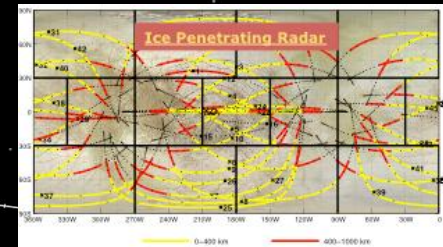
**Power**

\* Depends on Launch Opportunity and Launch Vehicle



# Europa Multi-Flyby Mission Coverage

## 13F7-A21 Trajectory



- Above 1,000 km → 2
- 250 km to 750 km → 6
- 80 km to 100 km → 9
- 50 km → 18
- 25 km → 10

### Spacecraft Trajectory

- 25 km  $\leq r_{alt} \leq 50$  km
- 50 km  $< r_{alt} \leq 400$  km
- 400 km  $< r_{alt} \leq 1000$  km
- 1000 km  $< r_{alt} \leq 4000$  km



# Questions?

